

Having thus described the preferred embodiments, the invention is now claimed to be:

1. A dose-modulated irradiating system for an x-ray tube with a cathode including a filament that generates electrons which are focused into a beam and an anode that generates x-rays responsive to the electron beam, the dose-modulated irradiating system further including:

at least one electrostatic control electrode arranged to electrostatically reduce an intensity of the electron beam; and  
a biasing means for applying a time-varying electrical bias to the electrostatic control electrode to vary the intensity of the electron beam.

2. The dose-modulated irradiating system as set forth in claim 1, wherein the electrostatic control electrode includes an electrostatic grid with grid electrodes arranged for steering the electron beam responsive to an applied differential potential.

3. The dose-modulated irradiating system as set forth in claim 1, further including:

a current-modulating means for applying a time-varying filament current through the filament; and

a control means for controlling the biasing means and the current-modulating means to produce a selected time varying intensity of the electron beam.

4. The dose-modulated irradiating system as set forth in claim 3, wherein the control means concurrently invokes the biasing means and the current-modulating means to vary the filament current simultaneous with the time-varying electrical bias on the electrostatic control electrode cooperatively producing the selected time varying intensity of the electron beam.

5. The dose-modulated irradiating system as set forth in claim 1, further including:

a rotating gantry on which the x-ray tube is disposed, the rotating gantry defining an examination region into which the x-ray tube transmits an x-ray beam;

a two-dimensional x-ray detector arranged across the examination region from the x-ray tube that measures a spatially-varying intensity of the x-ray beam after the x-ray beam passes through the examination region; and

a processor that reconstructs a computed tomographic image of an imaging subject disposed in the examination region based on the spatially-varying intensity of the x-ray beam measured by the x-ray detector at a plurality of positions of the x-ray source.

6. The dose-modulated irradiating system as set forth in claim 5, wherein the electrostatic control electrode includes an electrostatic grid with grid electrodes arranged about the filament, the dose-modulated irradiating system further including:

a second biasing means for applying a switched difference electrical bias to the grid electrodes to wobble the electron beam between alternating focal spots.

7. The dose-modulated irradiating system as set forth in claim 5, further including:

a filament current controller that applies a time-varying filament current through the filament; and

a controller that controls the biasing means and the filament current controller to produce a selected time varying radiation dosage applied to the imaging subject.

8. The dose-modulated irradiating system as set forth in claim 5, further including:

a filament current controller that applies a time-varying filament current through the filament;

a feedback element that computes a control signal corresponding to a rate of radiation delivered to the imaging subject based on the spatially-varying intensity of the x-ray beam measured by the x-ray detector; and

a controller that controls the biasing means and the filament current controller to produce a substantially constant control signal.

9. The dose-modulated irradiating system as set forth in claim 1, wherein the electrostatic control electrode includes paired grid electrodes arranged on opposite sides of the filament, and the electrostatic control modulator additionally applies a switched differential electrical bias component applied to the grid electrodes that causes a wobbling of the electron beam.

10. The dose-modulated irradiating system as set forth in claim 1, wherein the electrostatic control electrode includes a Wehnelt cylinder.

11. The dose-modulated irradiating system as set forth in claim 10, further including:

an electromagnetic deflector that selectively deflects the electron beam.

12. The dose-modulated irradiating system as set forth in claim 1, further including:

a computed tomography imaging scanner on which the cathode, the anode, and the electrostatic control electrode are mounted as a unitary x-ray tube unit.

13. A method for dose-modulating an output of an x-ray tube that includes a cathode having a filament that generates electrons which are focused into a beam, an anode that generates x-rays responsive to the electron beam, and an

electrostatic control electrode that electrostatically adjusts an intensity of the electron beam, the method including:

applying a time-varying electrical bias to the electrostatic control electrode to produce a first time-varying intensity modulation of the electron beam.

14. The method as set forth in claim 13, further including:

simultaneously with the applying of a time varying electrical bias, applying a time-varying filament current to produce a second time-varying intensity modulation of the electron beam, the first and second time-varying intensity modulations cascading to enhance a dynamic range over which the intensity of the electron beam is modulated.

15. The method as set forth in claim 14, wherein a ratio of a maximum x-ray beam intensity to a minimum x-ray beam intensity during the time varying intensity modulation is at least 8:1.

16. The method as set forth in claim 13, further including:

synchronizing the applying of the time-varying electrical bias with a rotation of a rotating gantry of a computed tomography apparatus on which the x-ray tube is arranged.

17. The method as set forth in claim 13, wherein the x-ray tube is a radiation source component of a computed tomography imaging scanner, the method further including:

imaging an imaging subject using the computed tomography imaging scanner;

during the imaging, measuring x-ray intensities using an x-ray detector component of the computed tomography imaging scanner;

estimating a temporally varying radiation dose delivery rate of x-ray radiation delivered to the imaging subject during the imaging based on the measured x-ray intensities; and

controlling the applying of the time-varying electrical bias during the imaging based on the estimated temporally varying radiation dose delivery rate.

18. The method as set forth in claim 17, wherein the controlling step controls the applying of the time-varying electrical bias to maintain a selected generally constant radiation dose delivery rate.

19. The method as set forth in claim 13, wherein the x-ray tube is a radiation source component of a computed tomography imaging scanner, the method further including:

imaging an imaging subject using the computed tomography imaging scanner, the applying of the time-varying electrical bias to the electrostatic control electrode being performed during the imaging to provide modulation of a radiation delivery rate.

20. The method as set forth in claim 19, further including:

controlling a filament current of the cathode to produce a second time-varying intensity modulation of the electron beam, the first and second time-varying intensity modulations of the electron beam being temporally coordinated to provide the modulation of the radiation delivery rate.

21. The method as set forth in claim 20, wherein the electrostatic control electrode includes an electrostatic grid with grid electrodes arranged about the filament, the method further including:

applying a switched differential electrical bias to the grid electrodes concurrently with the applying of the time-varying electrical bias to wobble the electron beam.

22. The method as set forth in claim 13, wherein the time varying electrical bias applied to the electrostatic control electrode is an analog time varying electrical bias.